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Original empirical article

THE ESTIMATION OF SHOULDER REGULARITY IN TOP ATHLETES BY DETERMINING THE SHOULDER ANGLE AND THORACAL ANGLE IN THE IMAGEJ DIGITAL PROGRAM*

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Abstract. *The research was conducted at the Faculty of Sport and Physical Education in Niš and during the regular athletic trainings of the Athletic Association of Serbia, on a group of athletes which consisted of 26 male individuals with top results in particular disciplines. The determination of the shoulder angle (SA) was carried out between the line that connects the acromial point at the basis of the neck and the horizontal axis on both left and right side; the thoracic angle was determined between the acromial distance and the line that connects the acromial point with the umbilicus on both the left and right side. The ImageJ program was used on the set of digital photographs in the frontal aspect of the participants. The mean value of the SA on the left and right side in top athletes is in accordance with the anthropometric standards. There is no statistically significant difference in the angle values among the short, medium and long distance runners. If separate values of the angles are observed, the most regular position of the shoulders can be found among jumpers and short track runners, and the most irregular one in pitchers (disc and ball). The higher or lower SA changes the TA on the corresponding side so an irregular angle is formed which originates when the acromial points are joined with the umbilicus. The method applied in measuring the angles, the ImageJ digital program, is simple, precise and objective and it can be used in the research of anthropometric parameters.*

Key words: *top athletes, shoulder angle, thoracic angle, ImageJ.*

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INTRODUCTION

Anthropometry is the science of taking quantitative measurements of human body dimensions. It consists of static, functional and strength anthropometry. Determining angles and distances or breadth is a part of static anthropometry (Peebles, and Beverley, 1998). Anthropometric measuring is necessary in many fields of human work such as ergonomics, anthropology, bio-mechanics, medicine and sports. Sports anthropometry has developed from the techniques and results of general physical anthropology. Continuous progress in the methods of sports training, and consequently in athletic performance, and the changes in athletic rules and equipment, have developed a need for the investigation of human biological factors that may have a role in competitive sport performance (Meszaros, Mohacsi, Szabo & Szmodis, 2000).

The analytical approach in sport anthropometry has only become dominant during the past 10 years; digital imaging applied in anthropometry is important for understanding the human body and posture (Herrington, Horsley and Christer, 2010). A large number of image processing tools with varied capabilities are available. ImageJ, which is available as a freeware, is such a tool. It is a public domain, Java-based image processing program developed at the National Institutes of Health *http>//en. wikipedia.org/wiki/ImageJ*. ImageJ was designed with an open architecture that provides extensibility via a Java plug-in and recordable macros (http:// en.wikipedia.org/wiki/ImageJ). ImageJ can be run as an online applet. Downloadable distributions are available for Microsoft Windows and they have a simple protocol *http:// prometheuswiki.publish.csiro.au/tiki-index. Php? Page= PROTOCOL%3A+ Makin… 24. 4. 2011.*

The position of the shoulder girdle and the regularity of the thorax on the frontal aspect determine the angle of the shoulder and thoracic angle. The regularity of the triangle determined with the acromial points and umbilicus indicates the regularity of the thorax in the frontal aspect. The triangle can be equilateral, isosceles or irregular. The shape of a triangle is determined by the size of the angles at the base, that is, on the points on the left and right acromions. It can be assumed that there is a connection between the shoulder angle and thoracic angle and that their relation determines the regularity of the shoulders.

The group of athletes includes runners, pitchers and jumpers. Runners and jumpers do not directly engage their shoulders. However, they are directly engaged in the case of the pitchers, especially the right shoulder among the right-handed, while the left shoulder is engaged among the left-handed. We think that it would be important to determine the SA and TA left and right by an objective method such as the digital ImageJ program (Bonetto, Comis, Formiconi and Guarraaciono, 2003). In that way we would define the type of the described triangle on the front wall of the thorax, that is, whether the shoulder girdle in top athletes deviates from the one in non-athletes.

METHODS

The research has been conducted at the Faculty of Sport and Physical Education in Niš and during the regular athletic trainings of the Athletic Association of Serbia.

The participants

The research was carried out on a group of athletes which consisted of 26 individuals of the male sex, with top results in particular disciplines. They were aged from 18 to 21. This group was divided into runners (short, long and medium distance), 18 of them, 5 jumpers, and 3pitchers. The following parameters were determined: the shoulder angle (SA) and the thoracic angle (TA) on both the left and right side.

Instruments

We used the anthropometer, a scale for measuring weight, a digital camera and the digital program ImageJ, which is freely available, and was downloaded from *htt://rsb.info.nih.gov/ij*.

Procedures

The weight of the participants was measured with a classic scale and is expressed in kilograms. The height was determined by an anthropometer and is expressed in centimeters.

The body mass index (BMI) was determined according to the propositions of the National Heart, Lung and Blood Institute – United States (http://www.nhlbisupport.com/bmi/bmi-m.htm).

Then, statistical digital photographs were made, in the frontal anatomical position, with the "Casio FX" camera, which was placed at an optimal distance and optimal height from the participants. The participants were photographed under the same conditions, and the photographs were color with 2816 x 2112 pixels. The ImageJ program and the set of digital photographs of the frontal aspect were placed on the desktop for easier management. The option "angle" from the software system was used and its value was expressed in degrees.

The determination of the SA was carried out between the line that connects the acromial point with the base of the neck and the horizontal axis on both the left and right side. (Image 1) (Peebles and Beverley, 1998). The thoracic angle was determined between the AAD and the line that connects the acromial point with the umbilicus on both the left and right side, which was shown in Image 2. So, a triangle is formed on the frontal wall of the thorax with points on the acromion (left and right) up and the umbilicus (down) on which a point of the triangle is placed (Omkar, Kumar and Mudigere 2007a).

Statistical processing of the obtained data was carried out via the SPSS 10 program. The mean value and standard deviation were determined. Statistical significance was tested by the T-test for small independent samples; the correction was done between the SA and TA on both the left and right side. All the data were inserted into tables and graphically presented where necessary.

Image 1. The left shoulder angle in the ImageJ program

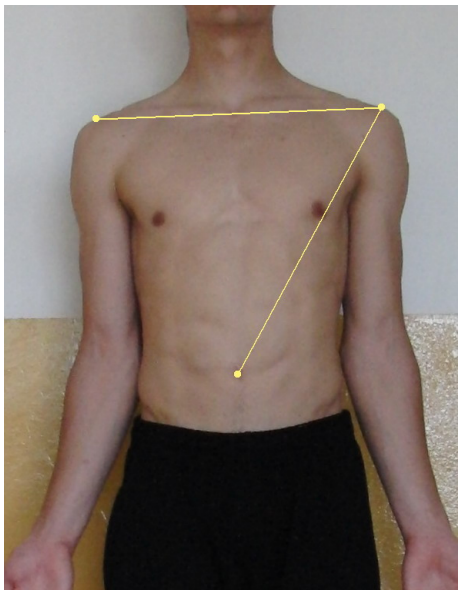

Image 2. The left thoracic angle in the ImageJ program

RESULTS

We presented the analysis of the SA and TA of the shoulder belt among athletes with top results (18 runners, 5 jumpers and 3 pitchers), analyzed in the ImageJ program.

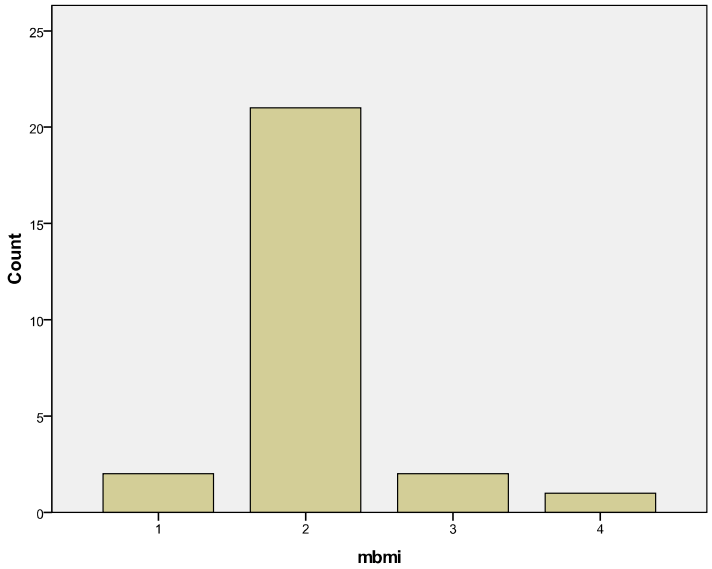

Diagram 1. MBMI - for male athletes with top results

According to diagram 1, it can be concluded that there were 2 malnourished participants (one short-track runner, one long-track runner), 21 participants with normal weight and 2 of them were overweight (2 pitchers) and one of them was obese (a pitcher).

Table 1. The SA and TA on the left and right side expressed in degrees (^{o}) in male athletes with top results

Angles	N	Minimum	Maximum	Mean	Std. Deviation
MLSA	26	12,80	27,12	20,78	3,18
MRSA	26	12,65	25,94	20,57	3,14
MLTA	26	58,42	64,98	61,96	1,55
MRTA	26	59,58	65,44	62,45	1,75
Valid N (listwise)	26				

LSA – left shoulder angle / **RSA** - right shoulder angle
LTA – left thoracic angle / **RTA** – right thoracic angle

Table 1 presents the mean values of SA and TA of the shoulder among the athletes: the LSA is 20,78±3,18, the RSA is 20,57 ^{o} ±3,14, the LTA is 61,96 ^{o} ±1,55 and the RTA is 62,45 ^{o} ±1,75. The minimal measure value in the SA was 12,65^o (RSA) and the maximal value 27,12^o (LSA). The minimal measure value in the TA was 58,42^o (LTA) and the maximal value was 65,44 ^{o} (RTA).

Table 2. The statistical significance of the SA and TA on left and right side

	Mean LSA	**Mean RSA**	**t-value**	**df**	**p**
Raz	20,77846	20,57154	0,236267	50	0,814191
	Mean LTA	**Mean RTA**	**t-value**	**df**	**p**
Raz	61,92462	62,38500	-1,06409	50	0,292402

LSA – left shoulder angle / **RSA** - right shoulder angle
LTA – left thoracic angle / **RTA** – right thoracic angle

Table 2 presents that there are no statistically significant differences between the mean values on both the left and right side of the measured angles in the case of the athletes.

Table 3. The shoulder and thoracic angle on right and left side expressed in degrees (^{o}) in long, medium and short distance runners with top results.

	Mean st	**Mean mt / lt**	**t-value**	**df**	**p**
BMI	21,74615	20,34000	1,680903	16	0,112196
LSA	20,15846	21,32400	-0,701147	16	0,493284
RSA	19,93846	19,39200	0,338736	16	0,739213
LTA	61,72583	62,61600	-1,01738	15	0,325102
RTA	62,73750	62,77000	-0,03359	15	0,973645

st – short distances / **mt** – medium distances / **lt –** long distances
LSA – left shoulder angle / **RSA** - right shoulder angle
LTA – left thoracic angle / **RTA** – right thoracic angle

There are no statistically significant differences between short-distance runners (men) and medium and long-distance runners in the above mentioned variables (the thoracic angle, up and down) in the examined sample. We are of the opinion that these results can be accepted as they refer to young and physically engaged individuals who are trained and with the adequately developed musculature of the shoulder belt that is predominately responsible for the appropriate posture of the thorax. Yet, it should be emphasized that the statistical sample is small as it refers to runners with top results. So, these results should be checked further.

Table 4. The size of the shoulder angle on the left and right side expressed in degrees (^{o}) in pitchers and jumpers with top results

Athletes	**N**	**Left shoulder angle (LSA)**	**Right shoulder angle (RSA)**
pitchers	3	24,78	21,57
		27,12	25,71
		22,89	22,25
jumpers	5	18,43	18,97
		18,43	17,20
		22,83	22,83
		18,65	25,94
		18,43	17,70

LSA – left shoulder angle / **RSA** - right shoulder angle

Table 4 presents the values of the angles in all the pitchers and jumpers. Due to the fact that there were only 3 pitchers, no statistical processing could be carried out, but it was noticed that the angle of the left shoulder in two instances (24,78º, 27,12º) was bigger than the right angle (21,57º and 15,71º), which indicates that the left shoulder was placed lower than the right one. In these cases the corresponding thoracic angles were also smaller so that the triangle on the frontal wall of the thorax was irregular.

In only 5 jumpers, it was noticed that the shoulder angles left and right in four cases were smaller than the mean value which indicated that the shoulders were lifted symmetrically. In only one case the angle of the right shoulder (25,94º) was bigger, which indicates that the right shoulder is far lower than the left one (18,43º) and that there was asymmetry of the shoulder belt.

Table 5. The size of the shoulder angle on the left and right side expressed in degrees (^{o}) in long, medium and short distance runners with top results.

Runners discipline	N	Left shoulder angle (LSA)	Right shoulder angle (RSA)
		18,43	17,20
		24,68	22,04
		19,65	17,10
		12,80	12,65
Short distances	13	16,99	16,82
		21,57	19,89
		20,22	20,10
		23,39	21,32
		17,59	20,73
		22,83	19,23
		21,50	22,83
		22,43	22,89
		19,98	19,57
		21,80	19,75
Medium distances	4	22,99	21,80
		15,95	14,04
		23,81	20,93
Long distances	1	22,07	20,44

st – short distances / **mt** – medium distances / **lt –** long distances
LSA – left shoulder angle / **RSA** - right shoulder angle

In Table 5 the values of the SA on both the left and right side are presented. It can be noticed that the left angle in two cases is smaller than X±SD in short distance runners, which indicates that the left shoulder assumed a higher position than the normal one. On the right side, in four cases, the SA was smaller than X±SD, which indicates that the right shoulder was positioned higher. Only in one case was the left shoulder angle higher than X±SD, which means that the left shoulder assumed the lower position than the normal one. In medum-distance runners, there was a case when the SA was smaller than X±SD and vice versa, which means that both shoulders were in a higher position. In the third case, the angles of both shoulders were smaller, which indicates that both shoulders were in a higher position.

DISCUSSION

The presented results in terms of determining the BMI, aimed at determining the nutrition level of the participants, point out that only the pitchers were in the obese category, which is in accordance with the findings of Kullberg Joel, Catrin von Below & Lars Lonn, 2007; Al-Attar, A. Salam, Rebeccal, L. Pollex and John F. Robinson, 2007; Nande P., Madafale V. and Vali S, 2009., who also concluded that the athletes – pitchers were obese.

The results that relate to the mean values of shoulder angle in athletes show that our findings are in accordance with the findings obtained by Peebles Laura and Beverley Norris, 1998, shoulder angle 65, and they were carried out in accordance with the population anthropometry. There are no statistically significant differences in the SA and TA in short, medium and long distance runners in the t-test for small, independent samples, which shows that the runners had a regular position of both shoulders. In the case of the jumpers, the SA on both the left and right side was in accordance with the standards, so it can be considered that the position of the shoulders in this group was the most regular. In the case of the pitchers, a higher SA was detected on the left side, which means a much lower left shoulder than the right one. If we consider the ball and disc pitchers, their right shoulder is more developed, that is, the muscular system that fixes the glenohumeral joint which is of crucial importance for the overall position of the shoulder. (Aydin, Y., Yildiz, I. and Yanmis, C., 2001). If the measured values of the SA are observed individually in the runners, the variations are higher than in the case of jumpers, and the angles are smaller, which indicates that the shoulders are positioned higher.

The triangle that can be noticed on the front wall of the thorax is equilateral if the angles are at a 60º in relation to the acromial points. If the angles are bigger or smaller, the triangle is isosceles. The higher or lower SA changes the TA on the corresponding side so that an irregular angle is formed which originates when the acromial points are joined with the umbilicus (Omkar S.N., Manoj Kumar M. and Dheevatsa Mudigere., 2007a; Omkar, S.N., Manoj Kumar, M. Ph.D. B.E. and Dheevatsa Mudigere B.E., 2007b).

The determination of angles in the ImageJ digital program was applied to the knee joints in rugby players (Hewett, T. E., Torg, J. S. and Boden, B. P., 2009) and to the shoulder joint while examining its mobility after rehabilitation (Suprak L, Osteming P, van-Donkelaar and A. Karduna., 2006); the authors point out that the acceptance of the method, objective work, as well as the necessary precision that it renders, which is in turn our experience, as well. We are of the opinion that this method is suitable for determining all the anthropometric parameters. It does not require equipment, as a camera and the ImageJ program are enough, as well as the knowledge and the experience of the researcher. In order to argue about the configuration of the thorax and its regularity in athletes, it is necessary to determine the parameters for posture in the same program on the sagittal images (profile aspect), (Linn J.M., 2001; Omkar, S.N., Manoj Kumar, M. Ph.D. B.E. and Dheevatsa Mudigere B.E., 2007b), which will be carried out in further research. The regularity or or irregularity of the thorax in athletes involved in different competitive disciplines can be estimated according to the longitudinal, angular and postural parameters.

CONCLUSION

The mean values of the SA on left and right side in athletes with top results is in accordance with anthropometric standards. There are no statistically significant differences in angle values among short, medium and long distance runners. If the individual values of the angles are observed, the most regular position of the shoulders can be found in the jumpers and short distance runners, and the most irregular in the pitchers (disc and ball). The nutrition level of athletes with top results was estimated by determining the BMI and it is noted that all the athletes are adequately nourished, except the pitchers, who are in the obese category. The method applied in measuring the angles, the ImageJ digital program, is simple, precise and objective and it can be used in the research of anthropometric parameters.

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ISPITIVANJE PRAVILNOSTI RAMENA KOD ATLETIČARA SA VRHUNSKIM REZULTATIMA ODREĐIVANJEM UGLA RAMENA I GRUDNOG UGLA U IMAGEJ DIGITALNOM PROGRAMU

Natalija Stefanović, Aleksandar Raković, Ivana Mladenović Ćirić, Snežana Pavlović, Daniel Stanković, Miloš Puletić, Bojan Jorgić

Istraživanja su sprovedena na Fakultetu sporta i fizičkog vaspitanja u nišu i na treninzima atletičara Atletskog saveza Srbije kod 26 atletičara pojedinaca muškog pola sa vrhunskim rezultatima. Određivan je ugao ramena (između linije koja spaja akromijalnu tačku sa početkom vrata i horizontale) i grudni ugao (između akromijalnoakromijalne distance i linije koja spaja akromijalnu tačku sa pupkom), a u cilju procene položaja ramena kod atletičara. Korišćen je ImageJ digitalni program i set fotografija atletičara u anatomskom položaju, koji su radi lakše manipulacije stavljeni na destop. Za određivanje veličine uglova iz programa je korišćena opcija "angle" , a uglovi su izražavani u stepenima. Srednje vrednosti uglova sa desne i leve strane bile su u skladu sa antropometrijskim standardima. U vrednostima uglova sa leve i desne strane kod trkača na kratke, srednje i duge staze nije bilo statistički značajnih razlika. Kod posmatranja pojedinačnih vrednosti uglova zapaža se da najpravilniji položaj ramena imaju skakači i trkači na kratke staze, a najnepravilniji bacači (disk i kugla). Veći ili manji ugao ramena korespondira sa promenom grudnog ugla čije je teme na akromijalnoj tački odgovarajuće strane. Primenjeni program ImageJ za merenje uglova je jednostavna, precizna i objektivna i može se koristiti u antropometrijskim merenjima.

Ključne reči: *vrhunski atletičari, ugao ramena, grudni ugao, ImageJ*